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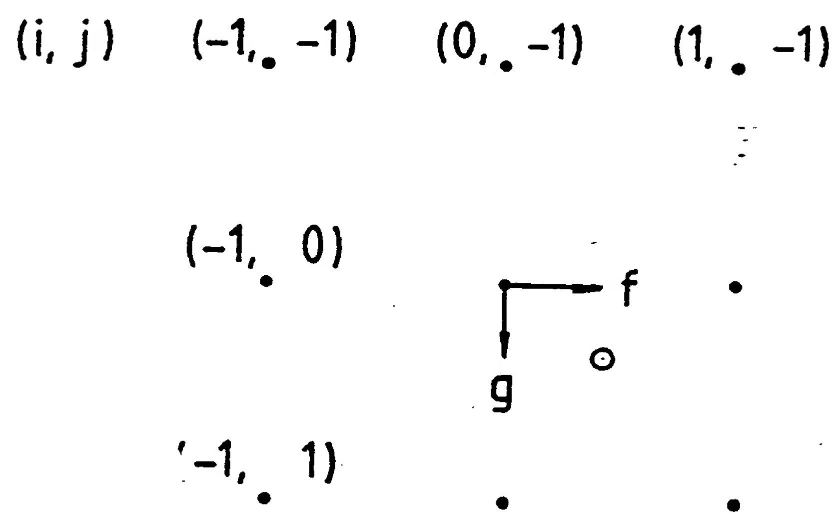
(54) Title: METHOD OF MOVING A PIXEL A SUBPIXEL DISTANCE



(57) Abstract

The invention relates to a method of moving a pixel a subpixel distance and is intended to be applied in picture coding methods to determine the value of a pixel located between the fixed pixels on the screen. The pixel value is calculated using a known motion vector and the pixel values located in the vicinity of the corresponding pixel in the previous picture. According to the invention at least 3x3 pixels from the previous picture are used and the pixel value is calculated as a sum of the previous pixel values weighted by coefficients depending of the motion vector. The coefficients are preferrably calculated as polynomials of the subpixel part of the motion vector.

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\+ Any designation of "SU" has effect in the Russian Federation. It is not yet known whether any such designation has effect in other States of the former Soviet Union.

TITLE OF INVENTION: METHOD OF MOVING A PIXEL A SUBPIXEL DISTANCE

FIELD OF THE INVENTION

The present invention relates to a method of moving a pixel a subpixel distance. Subpixel distance refers to a distance shorter than the distance between two adjacent pixels (pixel = picture element). The inve~~:ion is intended to be applied in the picture coding methods for determining the value of a pix located between the fixed pixels on the screen. This situation may occur in moving pictures where the pixels are moved arbitrary distances and thus, may end up between defined positions. The situation may also occur in conversion between different picture formats, so-called standard conversion.

STATE OF THE ART

According to the prior art usually 2x2 filters with so-called bilinear interpolation are used. The drawback with this technique is that it provides blurry pictures, especially in positions between two pixels. The reason is that the 2x2 filter has strong low-_ s characteristics. This drawback is overcome to a great extent with the invention utilizing 3x3-filters or greater.

4x4 filters are also previously known, however, not with functions for calculating coefficients of arbitrary positions but only for half pixel distances. However, the present invention provides a method for arbitrary pixel distances.

SUMMARY OF THE INVENTION

Thus, the present invention provides a method of moving

a pixel a subpixel distance, wherein the value of the pixel is calculated using a known motion vector and values of pixels located in the vicinity of the corresponding pixel in the previous picture. According to the invention at least 3x3 pixels from the previous picture are used and the pixel value is calculated as a sum of the previous pixel values weighted by coefficients depending on the motion vector. The coefficients are calculated as functions of the subpixel part of the motion vector, preferrably as polynomials. Further features of the invention are set forth in the accompanying claims.

The invention will now be described in detail referring to the enclosed drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1. is a diagram illustrating a 3x3 filter in accordance with the present invention.

Figure 2. is a diagram illustrating a 4x4 filter in accordance with the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The purpose of the present invention is to assign a value to a pixel which is to be calculated from the previous picture. It is assumed that a vector indicating the position in the old picture corresponding to the actual pixel is available. This situation occurs for instance in picture coding with prediction and standard conversion between different picture formats.

In figure 1, the positions of nine pixels in the previous picture are shown as dots and the pixel of which the value is to be calculated, is marked with a circle. Thus, in the new picture the circle corresponds to pixel in a fixed barpattern, similar to the nine dots. The motion vector (not shown) may be of arbitrary length. In calculating the new pixel value the integer parts of the motion vector are not used but only the fractional parts from the centre pixel, in the figure denoted by f and g for respective directions. For both f and g $-1/2 < f \leq 1/2$ and $-1/2 < g \leq 1/2$. In accordance with the invention the pixel value q is calculated as

$$q(n,k) = \sum_{i=-1}^{1} \sum_{j=-1}^{1} a_i r_j p(n+x+i, k+y+j)$$

where a_i and r_j are the filter coefficients, n, k are the coordinates in the new picture, $x+f$, $y+g$ is the motion vector, x and y being the integer part and f and g being the fractional part, p is the pixel value in the previous picture.

Thus, referring to figure 1, the pixel value of the pixel at the left top should be multiplied with a_{-1} and r_{-1} et cetera.

The problem is separable horisontally and vertically meaning that the coefficient $a_i r_j$ is a product of two coefficients a_i and r_j. The following coefficients for a 3x3-filter has been found:

$$a_{-1} = \frac{-2f + 3f^2 - |f^3|}{4}$$

$$a_o = \frac{2 - 3f^2 + |f^3|}{2}$$

$$a_1 = \frac{2f + 3f^2 - |f^3|}{4}$$

and r_j are identical functions of g.

In figure 2 the correspondning situation of a 4x4 filter is illustrated. For f and g $0 \leq f < 1$ and $0 \leq g < 1$. For a 4x4 filter in accordance with the invention the following coefficients are obtained:

$$a_{-1} = \frac{-7f + 12f^2 - 5f^3}{15}$$

$$a_o = \frac{15 - 3f - 27f^2 + 15f^3}{15}$$

$$a_1 = \frac{12f + 18f^2 - 15f^3}{15}$$

$$a_2 = \frac{-2f - 3f^2 + 5f^3}{15}$$

and r_j are identical functions of g.

The greater filter is chosen, the more information is obtained from the previous picture. In orders greater than four, however, the difference is hardly perceptible to the eye with the present screen technology.

The functions used to calculate the coefficients are chosen in a suitable way. The condition is that $\sum a_i = 1$ and $\sum r_j = 1$. It should be possible to find other functions as well, preferrably polynomials, using iteration, which would work acceptably.

The coefficients are preferrably stored in a look-up table for fast retrieval for all possible values of f and g.

Thus, the present invention solves the problem with the prior art, because the 3x3 filters and the 4x4 filters do not have the low-pass characteristics of the 2x2 filter. It is also possible with the present invention to move a pixel an arbitrary subpixel distance. The invention is only limited by the claims below.

CLAIMS

1. Method of moving a pixel a subpixel distance, wherein the pixel value (q(n,k)) is calculated using the known motion vector (x+f, y+g) and pixel values (p(n', k')) located in the vicinity of the corresponding pixel in the previous picture, **characterized** in that

at least 3x3 pixels from the previous picture is used, that the pixel value is calculated as a sum of previous pixel values weighted with coefficients depending on the motion vector.

2. Method according to claim 1, **characterized** in that the coefficients are calculated as functions of the motion vector subpixel part (f, g).

3. Method according to claim 1, **characterized** in that the coefficients are calculated as polynomials of the motion vector subpixel parts (f, g).

4. Method according to claim 1 or 2, **characterized** in that the coefficients are stored in a look-up table.

5. Method according to anyone of the preceding claims **chraracterized** in that 3x3 pixels from the previous picture are used, the value of the pixel being calculated as

$$q(n,k) = \sum_{i=-1}^{1} \sum_{j=-1}^{1} a_i r_j p(n+x+i, k+y+j)$$

where

the motion vector is (x+f, y+g); x and y are integers, $-1/2 < f \leq 1/2$ and $-1/2 < g \leq 1/2$,

p(n+x+i, k+y+j) are pixel values in the previous picture, and the coefficients being calculated as

$$a_{-1} = \frac{-2f + 3f^2 - |f^3|}{4}$$

$$a_o = \frac{2 - 3f^2 + |f^3|}{2}$$

$$a_1 = \frac{2f + 3f^2 - |f^3|}{4}$$

$$r_{-1} = \frac{-2g + 3g^2 - |g^3|}{4}$$

$$r_o = \frac{2 - 3g^2 + |g^3|}{2}$$

$$r_1 = \frac{2g + 3g^2 - |g^3|}{4}$$

6. Method according to claim 1-3, **characterized** in that 4x4 pixels from the previous picture are used, the pixel value being calculated as

$$q(n,k) = \sum_{i=-1}^{2} \sum_{j=-1}^{2} a_i r_j p(n+x+i, k+y+j)$$

where
the motion vector is (x+f, y+g); x and y are integers, $0 \leq f <\_1$ and $0 \leq g < 1$,
p(n+x+i, k+y+j) is the pixel value in the previous picture and the coefficients being calculated as

$$a_{-1} = \frac{-7f + 12f^2 - 5f^3}{15}$$

$$a_o = \frac{15 - 3f - 27f^2 + 15f^3}{15}$$

$$a_1 = \frac{12f + 18f^2 - 15f^3}{15}$$

$$a_2 = \frac{-2f - 3f^2 + 5f^3}{15}$$

$$r_{-1} = \frac{-7g + 12g^2 - 5g^3}{15}$$

$$r_o = \frac{15 - 3g - 27g^2 + 15g^3}{15}$$

$$r_1 = \frac{12g + 18g^2 - 15g^3}{15}$$

$$r_2 = \frac{-2q - 3q^2 + 5q^3}{15}$$

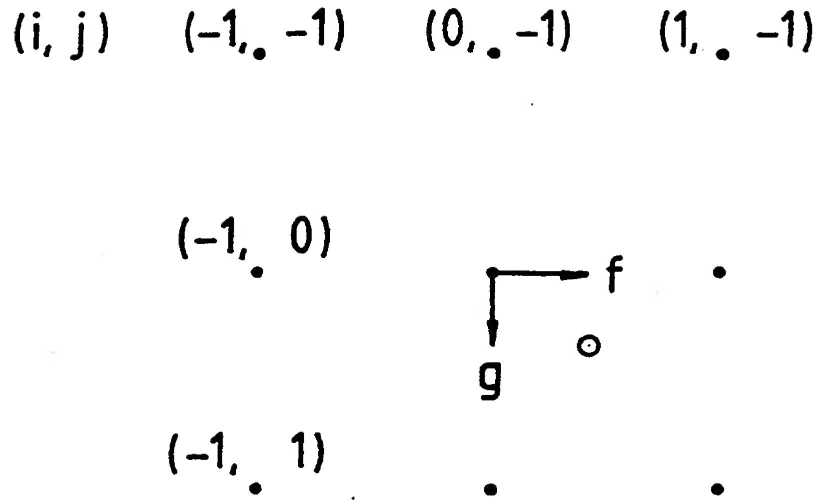

FIG. 1

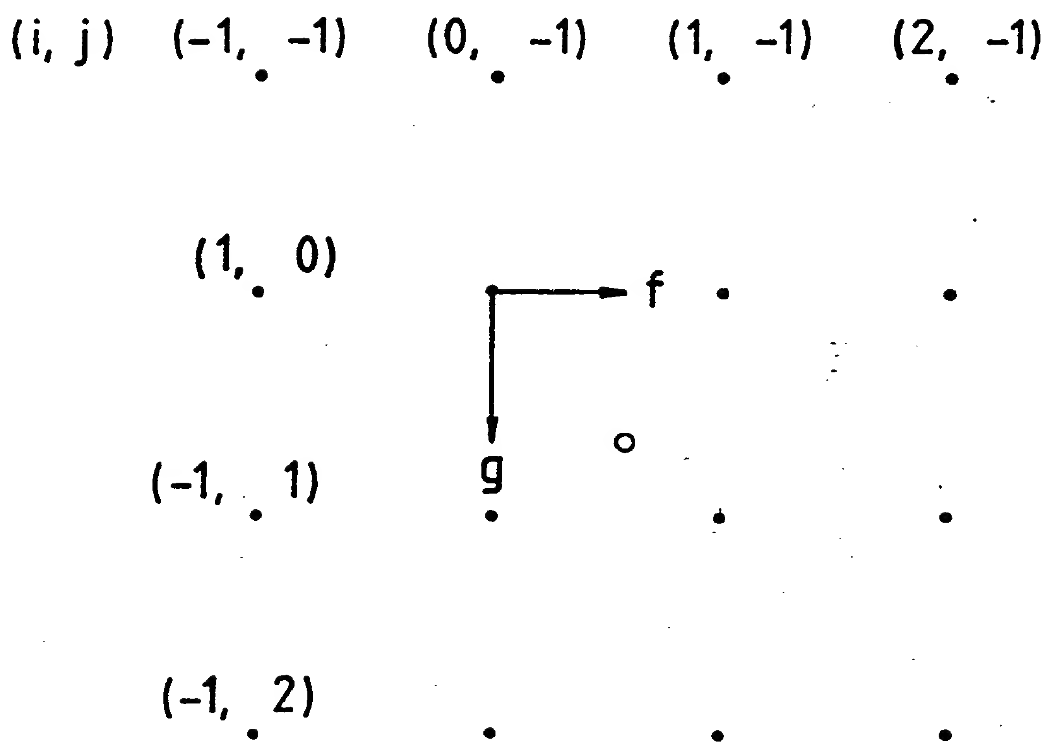

FIG. 2

INTERNATIONAL SEARCH REPORT

International Application No PCT/SE 91/00530

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC5: G 06 F 15/66

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
IPC5	G 06 F

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched[8]

SE,DK,FI,NO classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category *	Citation of Document,[11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
A	EP, A2, 0280316 (SONY CORPORATION) 31 August 1988, see the whole document --	1-6

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* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
15th October 1991	1991 -11- 05
International Searching Authority	**Signature of Authorized Officer**
SWEDISH PATENT OFFICE	JAN SILFVERLING

Form PCT/ISA/210 (second sheet) (January 1985)

ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.PCT/SE 91/00530

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the Swedish Patent Office EDP file on 91-08-30
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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP-A2- 0280316	88-08-31	AU-D-	1212288	88-09-01
		JP-A-	63208984	88-08-30
		JP-A-	63208985	88-08-30
		US-A-	4874347	89-10-17
		JP-A-	63213086	88-09-05